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Meynier, A.; Jacobsen, Charlotte; Thomsen, Birgitte Raagaard; Brestaz, P.; Ribourg, L.; Viau, M.; Genot, C.

*Publication date:*  
2014

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Meynier, A., Jacobsen, C., Thomsen, B. R., Brestaz, P., Ribourg, L., Viau, M., & Genot, C. (2014). *Lipid oxidation during instrumented dynamic in vitro digestion of marine oil-enriched milk*. Poster session presented at 12th Euro Fed Lipid Congress, Montpellier, France.

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# Lipid oxidation during instrumented dynamic *in vitro* digestion of marine oil-enriched milk

A. Meynier, C. Jacobsen\*, B.R. Thomsen\*, P. Brestaz, L. Ribourg, M. Viau, C. Genot,

The health benefits of n-3 long-chain polyunsaturated fatty acids (n-3 LC-PUFA) are well recognized. Foods enriched in n-3 LC-PUFA, are now available for the consumers. However, PUFA are prone to oxidation during processing and storage of the enriched-foods, but also during their digestion, and deleterious compounds can be formed both during both gastric and intestinal steps [1].

The aim of this study was to evaluate the formation of toxic aldehydes: malondialdehyde (MDA), 4-hydroxy-2-hexenal (4-HHE), 4-hydroxy-2-nonenal (4-HNE) during the *in vitro* digestion of marine oil enriched milk.

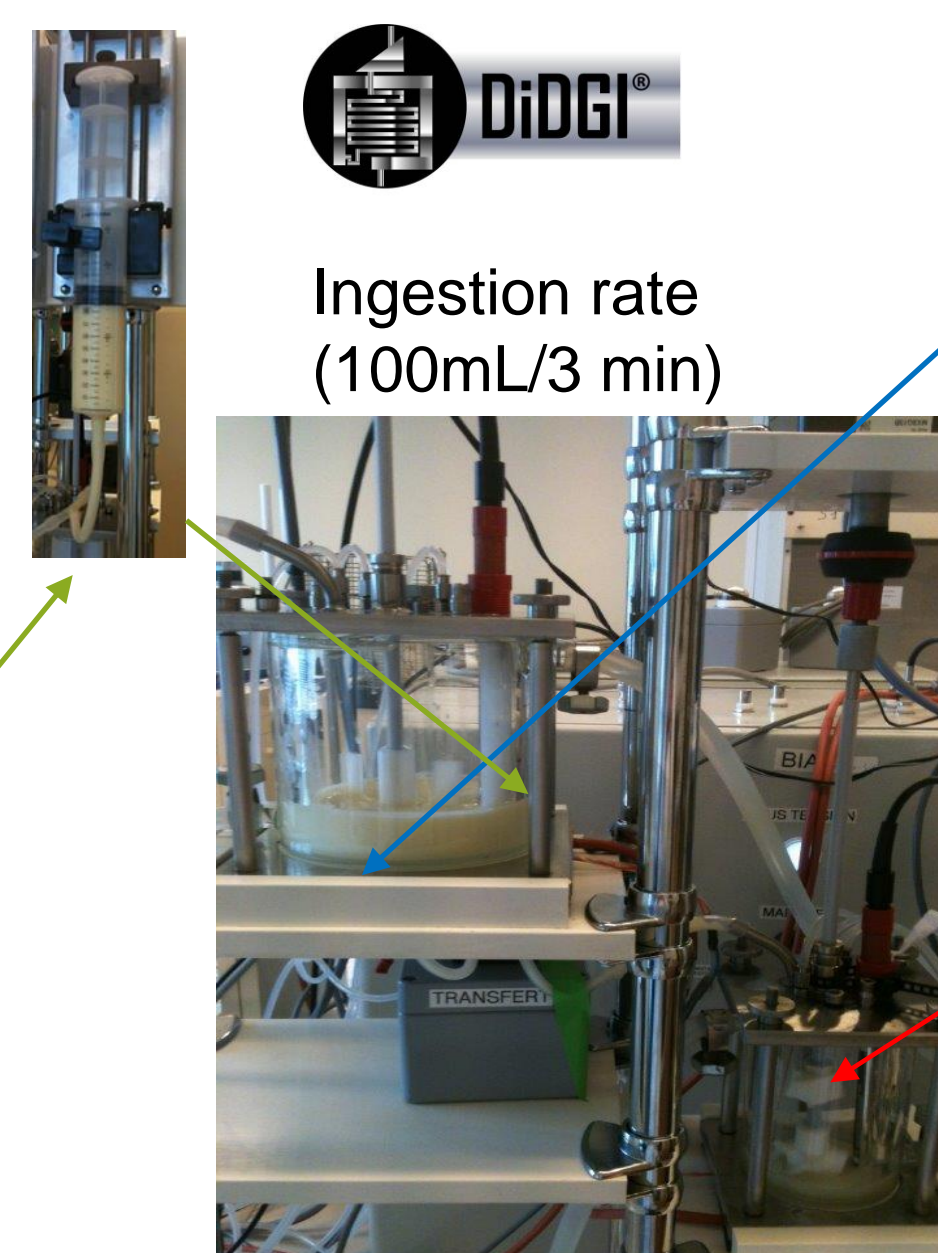
## Material & Methods

### Milk enrichment

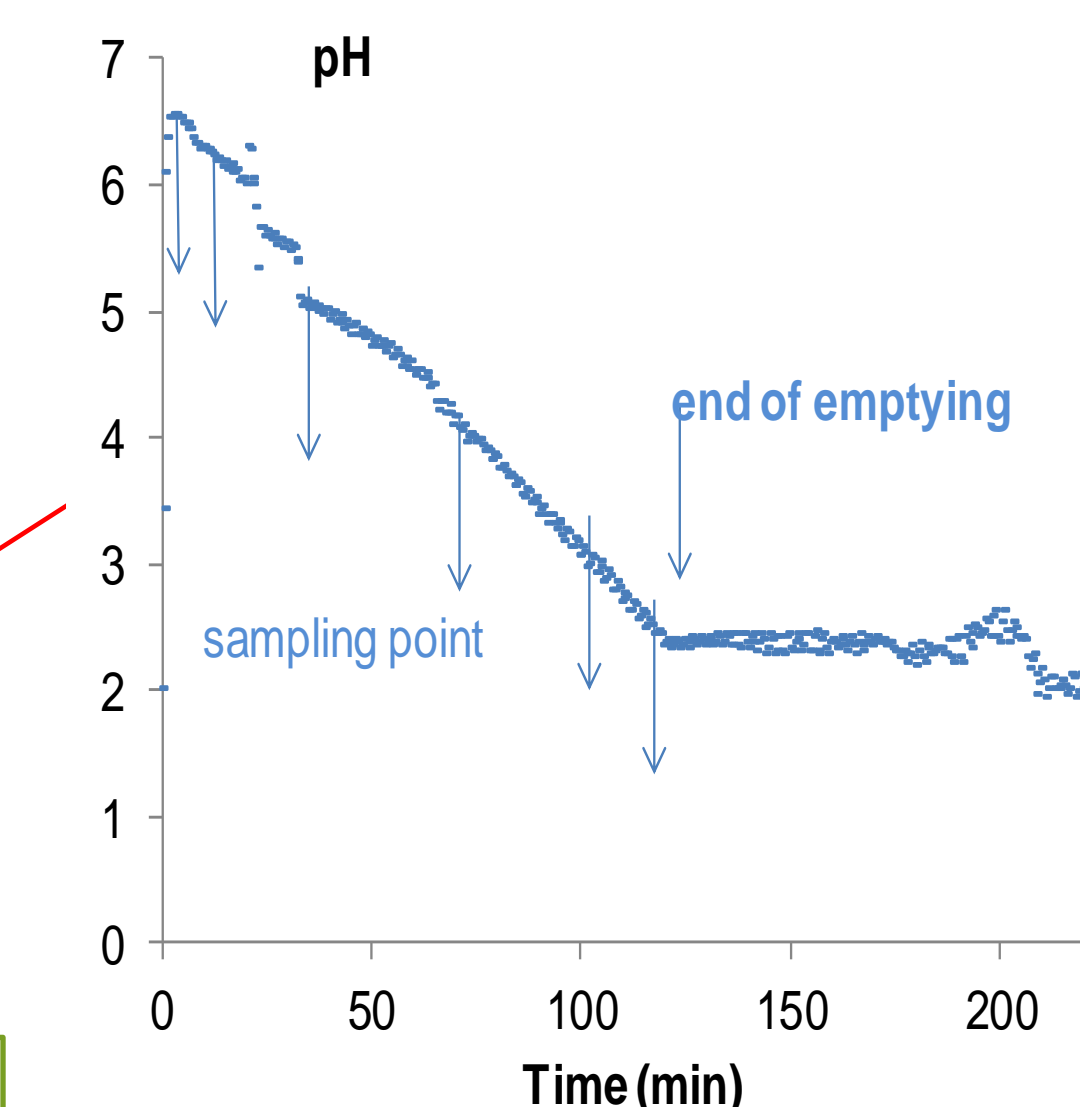
**Fish oil 0.5 % (w/w)**  
PV = 2.4 meq/kg ; AV = 7.55  
MDA: 68 nmole/g oil  
4-HHE: 0.8 nmole/g oil  
4-HNE: 0.18 nmole/g oil  
Tocopherols : 890 µg/g oil  
EPA + DHA : 11 % total fatty acids  
n-6/n-3 PUFAs : 0.26

Homogenized pasteurized milk  
1% fat  
Homogenization  
(300 bars, 2.5 min)

**Marine-oil enriched milk**  
1% milk fat, 0.5% fish oil

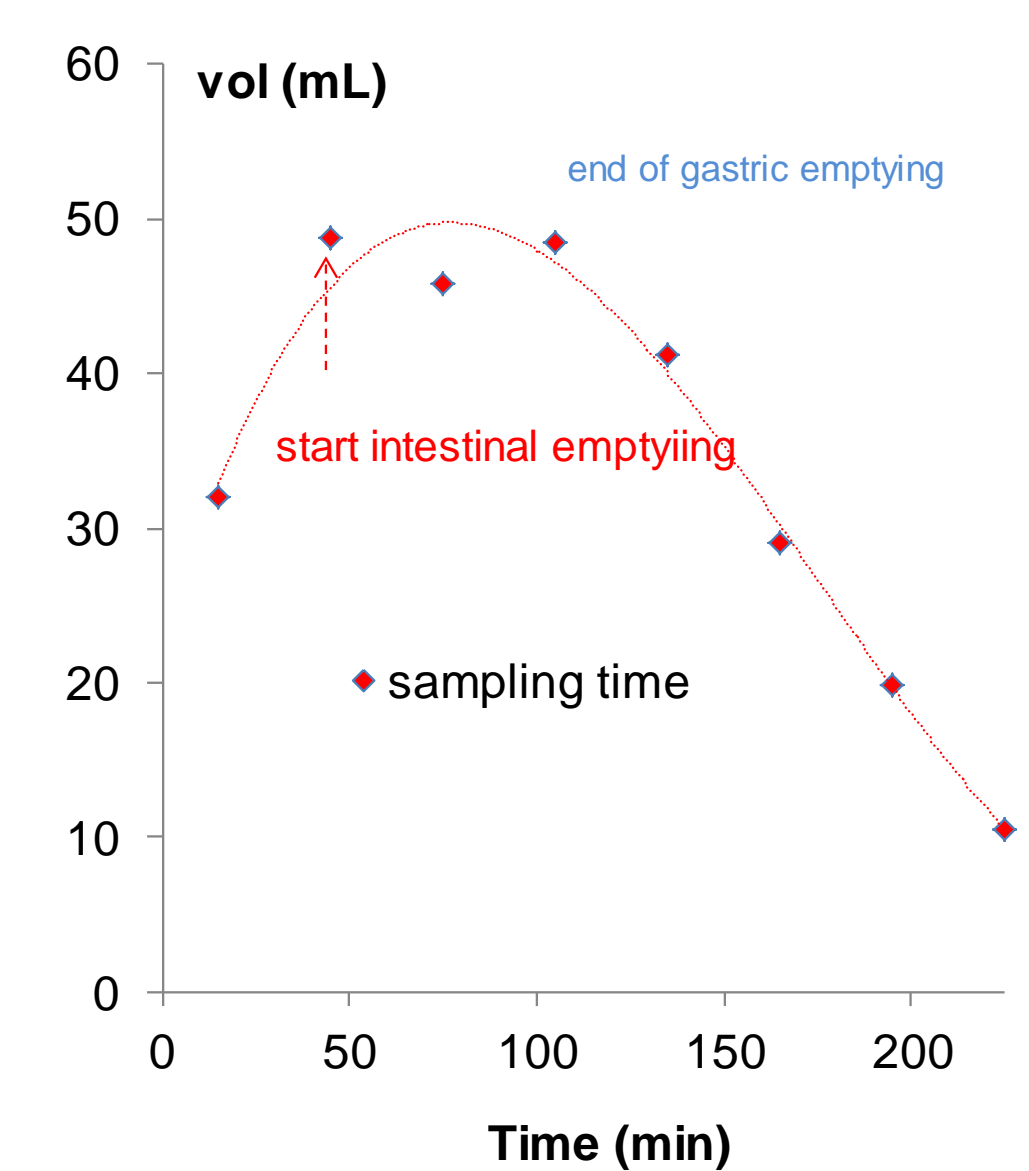


### Stomach



### Intestine

pH regulated at 6.5



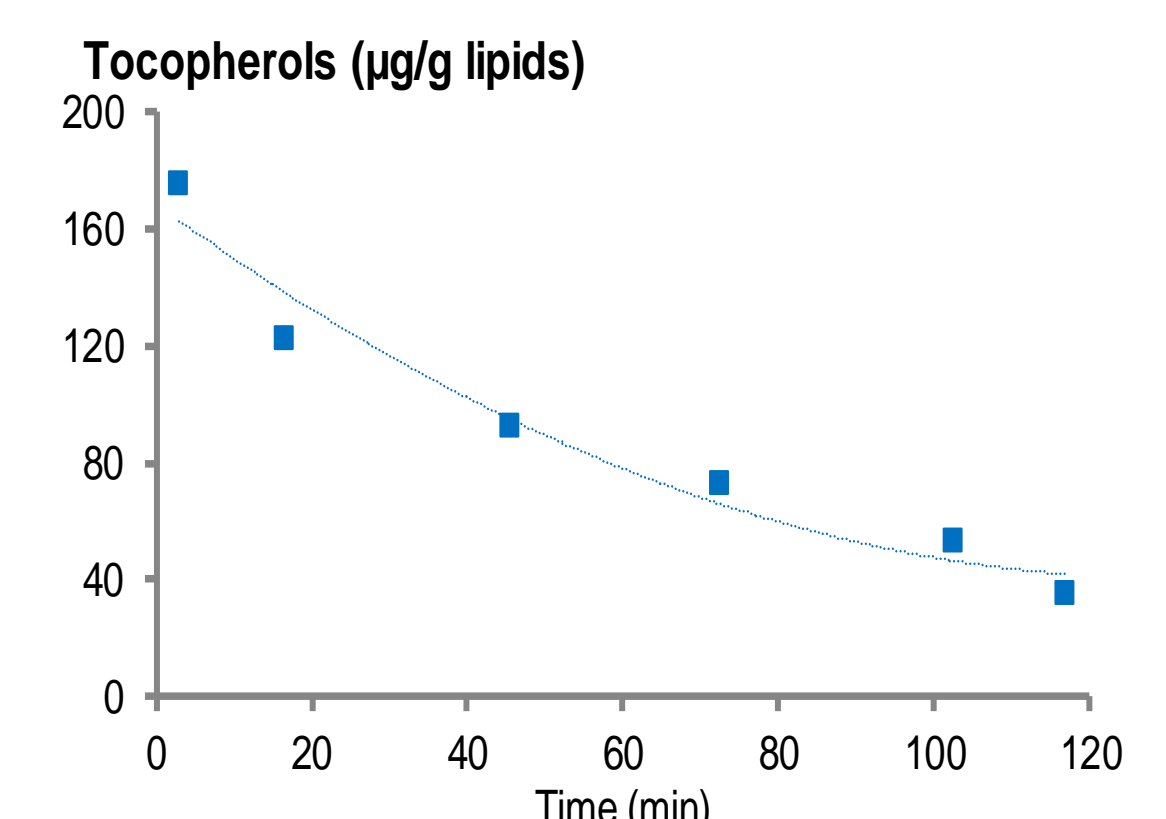
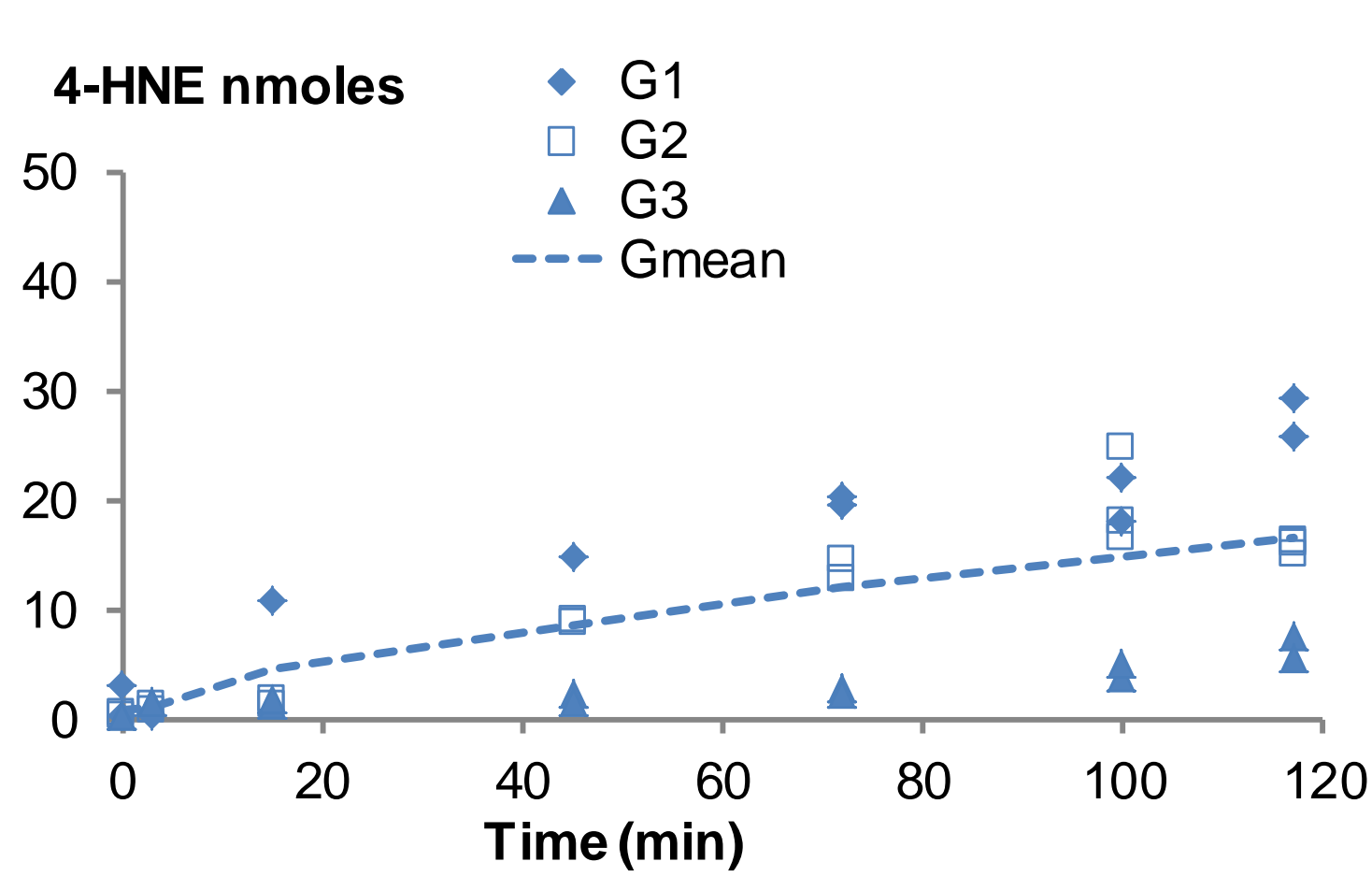
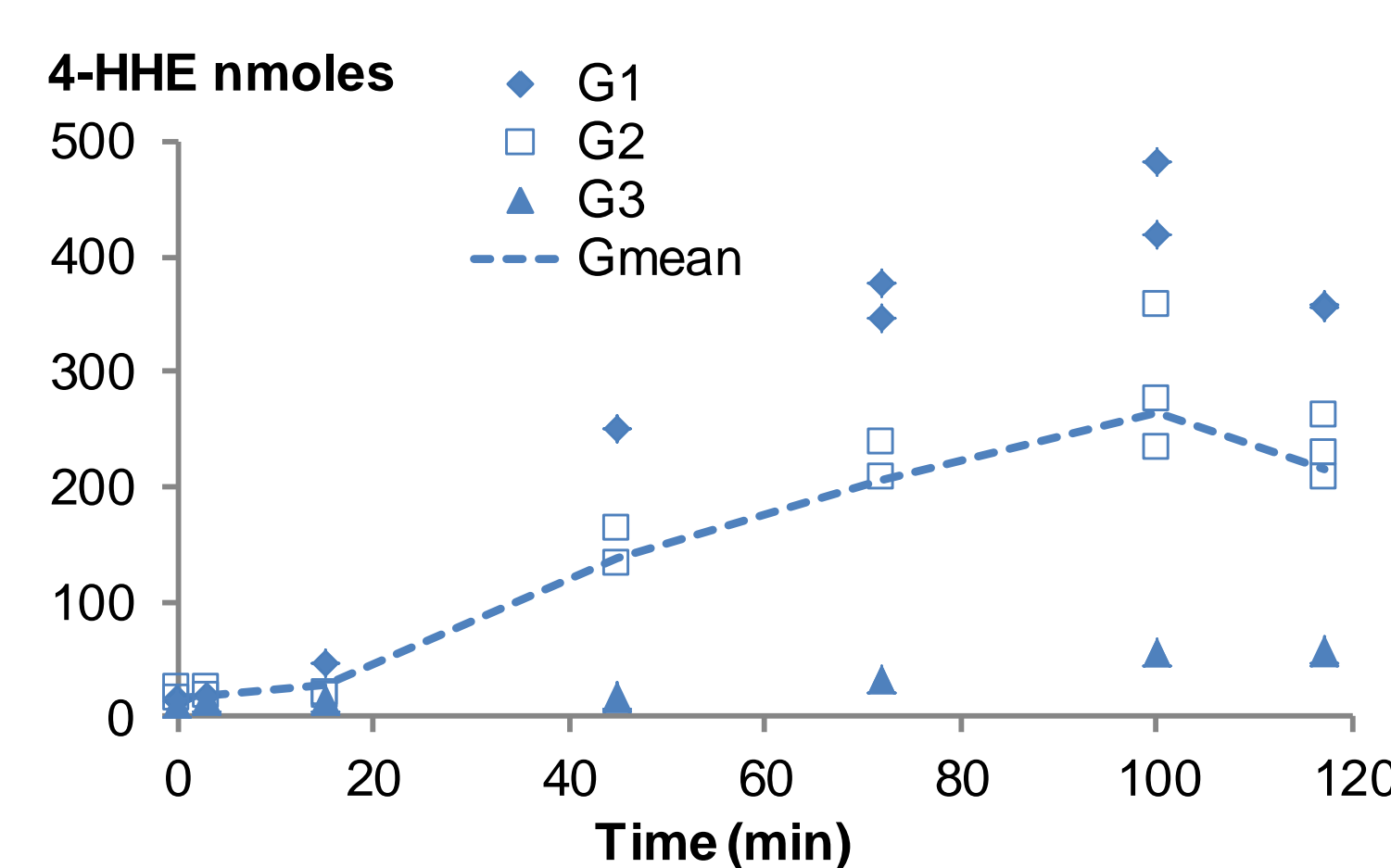
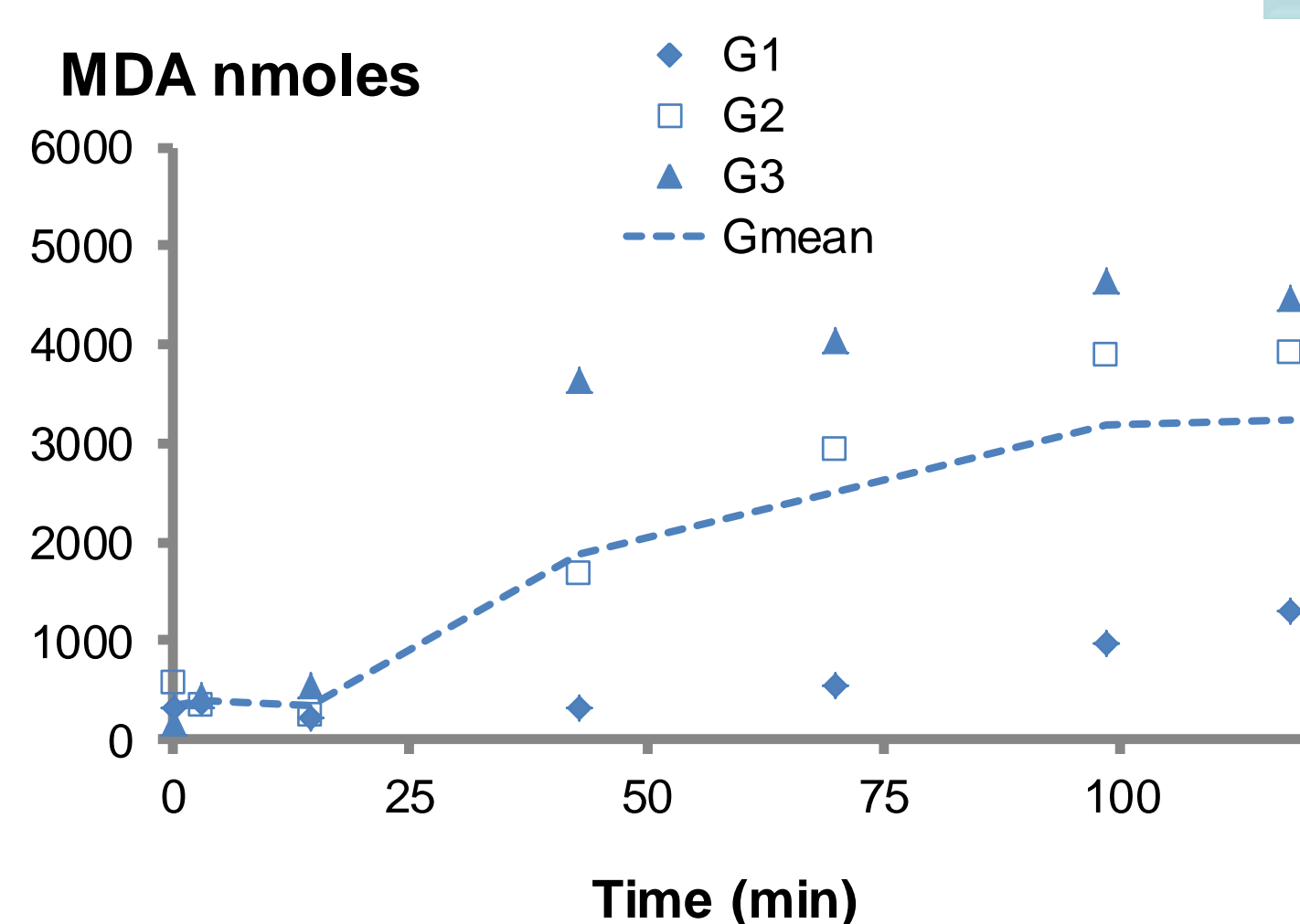
## Results & Discussion

Three digestions were performed independently on three marine oil-enriched milks prepared separately.

MDA, 4-HHE and 4-HNE were measured on the samples from the 3 experiments. The individual data obtained for MDA (left), 4-HHE (middle) and 4-HNE (right) during the gastric (blue symbols, G1, G2, G3) and intestinal steps (red symbols, I1, I2, I3) of each digestion are shown. The blue and red lines locate the mean values.

Total amounts in each compartment (nmoles) calculated from volumes of digestive media are presented.

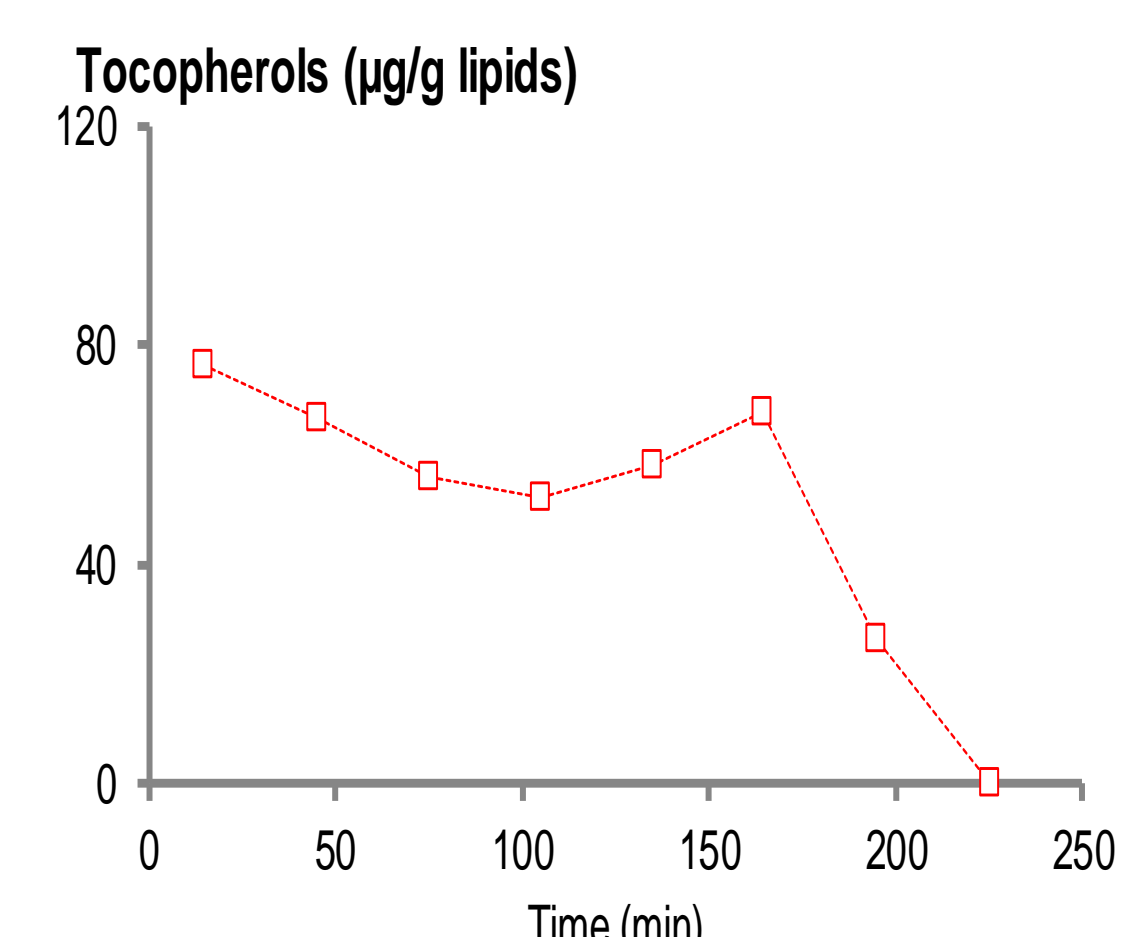
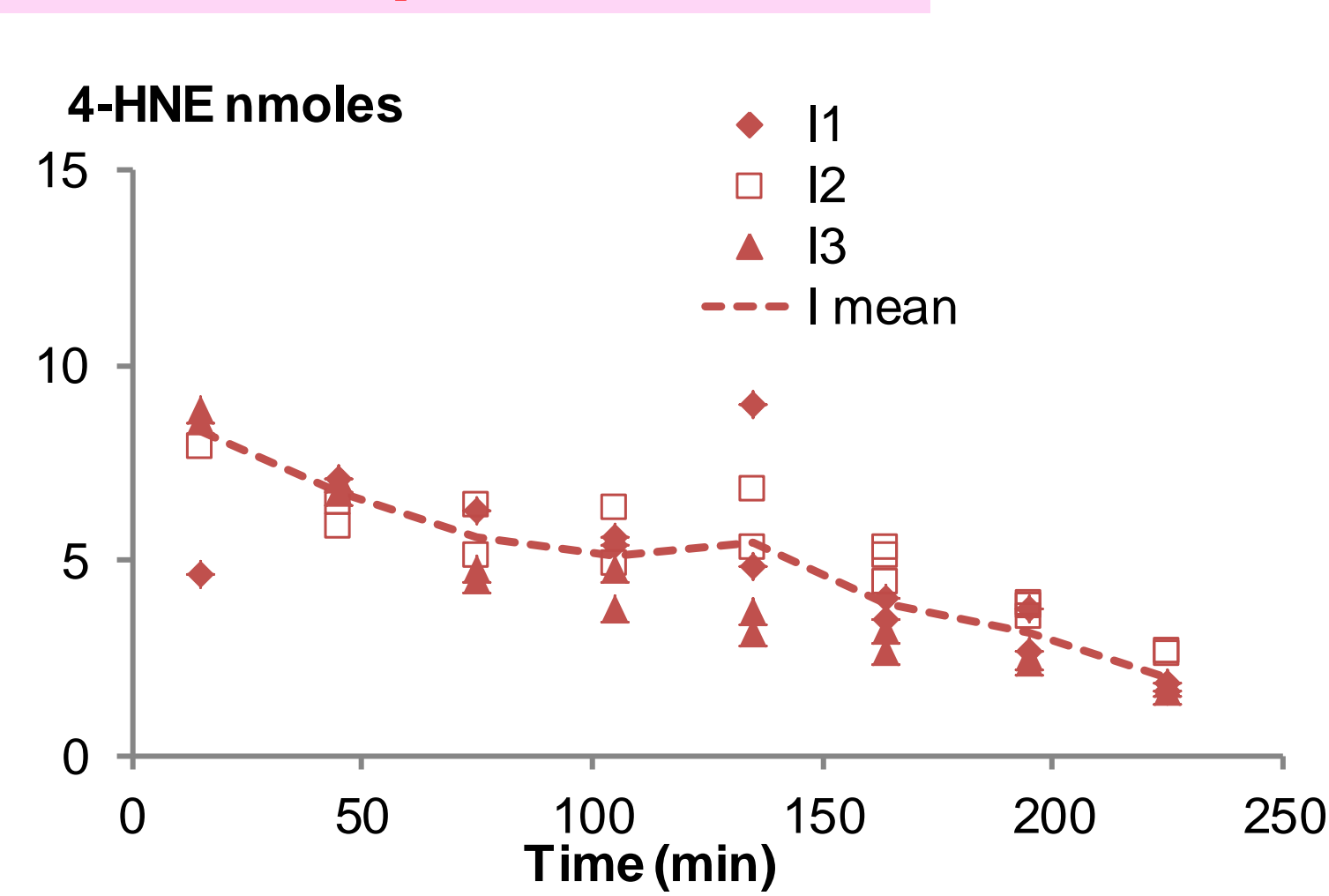
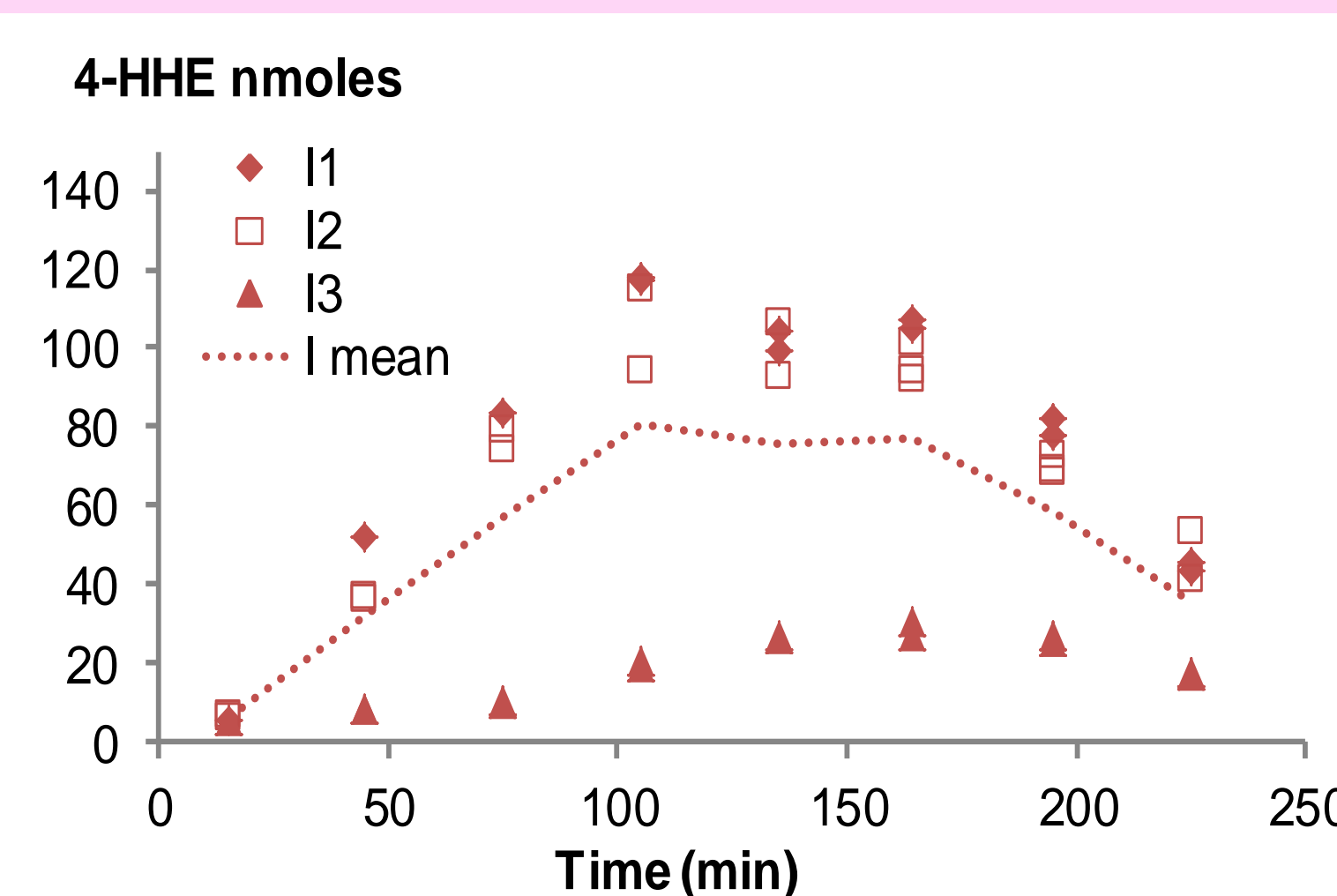
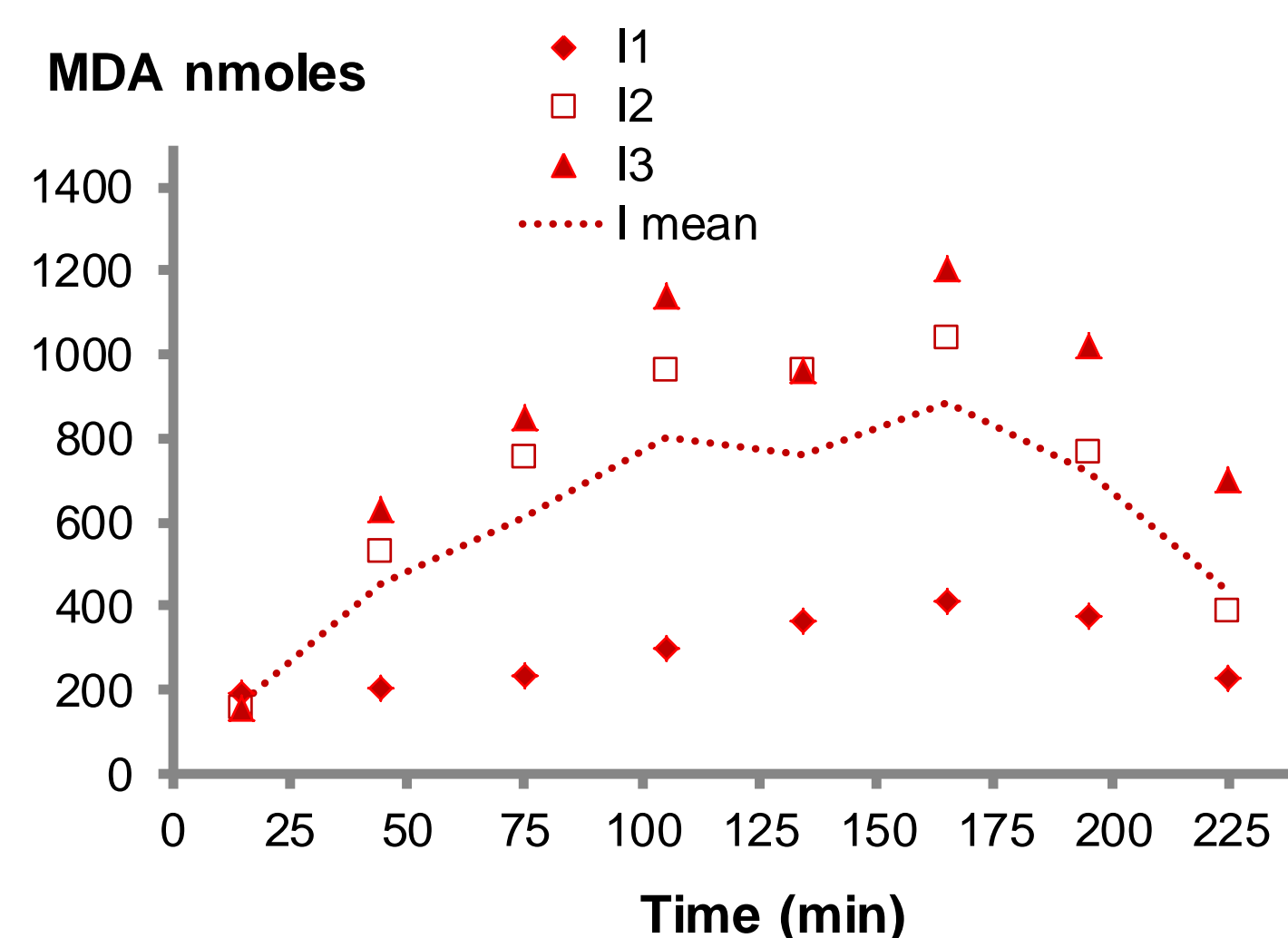
### Lipid oxidation in the stomach compartment



During the gastric step, toxic aldehydes such as MDA and 4-HHE were formed while tocopherols were consumed.

The results confirm that oxidation of the n-3 PUFAs of marine oil-enriched milk took place in conditions close to real gastric conditions (pH variation, 5), even in the absence of oxidation initiator such as heme iron.

### Lipid oxidation in the intestine compartment



Tocopherol concentrations remained fairly stable during most of the intestinal step. The decrease observed after 165 min is tentatively attributed to the high dilution of the lipids contained in the meal in those belonging to the digestive fluids.

MDA and 4-HHE concentrations increased continuously in the intestinal conditions. However, their concentrations were lower than in the gastric medium. It could result from the dilution by the digestive fluids and from the binding of the reactive aldehydes to the components of the medium, including the hydrolyzed milk proteins. The decrease of MDA and 4-HHE total amounts at the end of the intestinal step is linked to the decrease of the fluid volume (emptying). 4-HNE was not appreciably produced during intestinal digestion of marine oil-enriched milk.

Oxidation and production of MDA and 4-HHE continued during the intestinal simulated digestion.

## Conclusions

Toxic aldehydes (MDA >> 4-HHE >> 4-HNE) were formed during the gastric and intestinal steps of the *in vitro* digestion of the marine oil-enriched milk. Tocopherols were consumed mostly during the gastric step. Results must be confirmed by *in vivo* studies, to evaluate in the case of n-3 LC-PUFA enriched-foods, the health effects of the oxidative reactions during digestion.

## References

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